CASE 46128

This invention relates to the recovery of bitumen from tar sands. More specifically, the invention relates to the method of treating the oil froth obtained from the hot water extraction of tar sands.

Tar sands or bituminous sand is an aggregate of sand, clay, oil and water. The sand consists mainly of quartz particles of 100 to 200 mesh size and smaller, as well as particles of other minerals and clay occurring interbedded within the bituminous sand. The oil is viscous, naphthenic and of a specific gravity slightly greater than that of water. The oil content of the sand ranges up to and sometimes even exceeds 17 percent by weight. Rich bituminous sands from beds not invaded by water generally have a water content of about 3 to about 5 percent by weight which is probably present as a film around the sand particles with the oil surrounding the moist sand particle as an envelope.

Various methods for recovering and treating the tar sands have been proposed. However, in the method of the invention described herein the tar sand is mined and the oil or bitumen recovered therefrom by what is commonly referred to as the hot water extraction process. The purpose of the hot water extraction process is to free the bulk or major portion of the oil contained in the tar sands to produce a product effluent comprising bitumen with a minimum of water and entrained solids including sand. In the hot water extraction

process 185°F. water and steam are added to the tar sands to raise the sand temperature and to facilitate the break-down of sand lumps into a fine dispersed state. The sand is then passed through a mixer to further wet each sand particle and form a relatively stiff mixture referred to as a pulp. The pulp is then passed to a premix tank where it is flooded with additional 185°F. hot water to effect separating the bulk of the sand from the oil and form an oil-air-sand-water mixture which is then distributed on to the surface of a separation tank wherein an oil-water-air froth separates and floats at the top of the separation tank. The froth contains a considerable amount of entrapped air in addition to entrained finely divided sand and clay particles or silt contained in the tar sands.

The present invention is concerned primarily therefore with the method of treating the froth obtained from the hot water extraction steps to remove entrapped air therefrom to recover a liquid phase and the mixing of a suitable hydrocarbon diluent with the deaerated froth or recovered liquid phase prior to dehydrating in electrostatic treaters wherein final separation of water and sand from the oil is effected.

As discussed hereinbefore the froth comprises a mixture of oil, air, water and entrained finely divided solid particles comprising sand and silt particles. This froth, however, may not be passed directly to the dehydration zone comprising electrostatic treaters since the gravity of the oil and the presence of air is unsuitable for efficient separation of the oil from water. By removing the entrained or entrapped air first, it is then possible to use a relatively light hydrocarbon diluent rather than a heavier hydrocarbon

diluent to raise the gravity of the oil since the presence of air with the light hydrocarbon diluent is susceptible to fire and/or explosion hazards. The advantages of using a relatively light hydrocarbon diluent is many-fold in that substantially less of the hydrocarbon diluent is required to obtain a desired gravity, an economic advantage is realized since less diluent is required and the recovery of the diluent material is more economical.

In accordance with this invention, air is first removed from the froth obtained from the extraction of tar sands and thereafter a relatively light hydrocarbon diluent is mixed with the liquid phase containing the extracted oil or bitumen to obtain hydrocarbon material of desired gravity for separation from entrained water. More specifically, the froth is passed first to a deaeration zone or cell maintained at subatmospheric pressure and an elevated temperature. In one method of operation, steam is introduced into a liquid phase of oil, water and entrained solid particles maintained in the lower portion of the deaeration zone which liquid phase is formed by collapse of the froth, to heat the zone to a temperature not substantially above the boiling point of water at the pressure conditions maintained in the deaeration zone, thereby effecting collapse or bursting of air and water bubbles and the release of the air from the froth and liquid phase in the deaeration zone. In this particular embodiment the steam performs a dual function of heating the deaeration zone concomitantly with stripping of released air from the froth and liquid phase. That is, the major portion of the introduced steam gives up heat and condenses to become a part of the liquid phase with the remaining minor portion passing

upwardly through the liquid phase and froth to strip released air therefrom, which is then removed from the upper portion of the deaeration zone.

In another embodiment it is contemplated indirectly heating the deaeration zone with a heat coil emersed in the liquid phase so that a portion of the water in the liquid phase will be vaporized and act as the stripping medium to remove released air. In this latter embodiment, it is contemplated effecting the release of air, either with or without the addition of extraneous steam, and employing pressures about atmospheric or above.

In addition to controlling the temperature-pressure relationship in the deaeration zone to break-up air and/or water bubbles to release entrapped air, relatively mild stirring of the liquid phase is effected by one or more suitable stirrers. Stirring during deaeration aids in the release of water and air vapors so that the volume occupied by a given weight of extracted oil or bitumen is substantially reduced. However, it is important to employ relatively mild stirring conditions since relatively vigorous stirring would tend to form an undesired emulsion of oil and water.

By the above method the froth becomes deaerated to form a liquid-oil-water phase which, upon further treatment in the deaeration zone as described herein, becomes sufficiently deaerated for removal and further treatment in accordance with this invention. The deaerated liquid phase is then removed from the deaeration zone and passed to a diluent mixing and heating zone employed in conjunction with a dehydration zone. The purpose of the dehydration zone is to separate the liquid oil-water phase into an oil-rich phase and a water-rich

phase so that the oil may be recovered for further treatment as desired.

In accordance with this invention, the oil-water liquid phase recovered from the deaeration zone is passed to the diluent mixing and heating zone associated with the dehydration zone wherein a relatively light hydrocarbon diluent is mixed with the liquid phase to form a hydrocarbon mixture having a gravity in the range of from about 15 to about 25° API. Suitable heating of the mixture is also accomplished in the mixing zone to maintain the mixture at a temperature in the range of from about 200 to about 300°F. and suitable for passage to the dehydrating zone while maintaining the pressure of the mixing zone from about 5 to about 50 pounds above the vapor pressure of the hydrocarbon water mixture.

Various hydrocarbon diluent materials may be employed in the method of this invention, however, it is preferred to employ a relatively low-boiling hydrocarbon material such as relatively low-boiling naphtha materials, for example coker naphtha.

Heating of the mixture in the diluent mixing zone may be accomplished in various ways and will be dependent in part upon the temperature of the hydrocarbon diluent stream, as well as the temperature of the liquid phase containing the oil extract or bitumen passed to the mixing zone. When employing storage facilities intermediate the deaeration zone and the diluent mixing zone, the heat requirements of the process will be somewhat higher than when passing the relatively hot liquid phase from the deaeration zone directly to the diluent mixing zone. However, the hydrocarbon diluent may be employed to supply a relatively large amount of the

heat required to bring the mixture up to a desired temperature. In any of these arrangements, it is important that the hydrocarbon diluent be added to the liquid phase either in the diluent mixing and heating zone or just prior to passing the mixture to the mixing zone since it has been observed that the rate of settling of finely divided solid particle material entrained with the liquid phase upon addition of the hydrocarbon diluent material is relatively rapid. Therefore, to facilitate handling and to assure flow of the diluted liquid phase the diluent mixing zone is positioned with respect to the dehydrating zone to assure gravity flow from the bottom of the vessel into the dehydrating zone. Heating of the diluent mixing zone to an elevated temperature in the range of from about 200°F. to about 300°F., preferably about 260°F., is accomplished in part as discussed above by heating the diluent material at an elevated temperature and providing the diluent mixing zone with a heating coil arrangement through which a suitable hot fluid material is passed. More specifically, a steam coil may be employed to indirectly heat the liquid phase of material in the diluent mixing zone. In addition to the above, the diluent mixing zone is provided with one or more stirrers to provide agitation of the mixture, however, the stirring or agitation of the mixture is to be relatively mild for the reasons discussed hereinbefore with respect to the deaeration zone. Provisions are also made to admit relatively high pressure steam compatible with the pressure in the diluent mixing zone to the vapor space thereof and above the liquid phase to scavange or sweep out any air released from the liquid phase during mixing with the hydrocarbon diluent.

The dehydration zone comprising an electrostatic

treater employed in conjunction with the method of this invention is a part of this invention only with respect to the location or positioning of the diluent mixing zone associated therewith to provide for gravity flow of the diluted liquid phase as described herein. In the electrostatic treater, dehydration and demineralization is accomplished by means of an electrostatic field. The waste products including sand, water and a small amount of unseparated bitumen or oil is discharged from the bottom of the dehydration zone and sent to disposal. The recovered oil and diluent is removed from the upper portion of the dehydration zone and passed for further treatment in, for example, a delayed coking unit.

Having thus given a general description of this invention, reference is now had to the drawing by way of example which presents a preferred embodiment thereof.

The hot water extraction process to recover bitumen or oil from the tar sands in the form of a froth comprising oil, air, water and sand is effected in the zone identified by numeral 2. The froth is recovered from zone 2 at a temperature of about 175°F. and flows by gravity through conduit 4 to deaeration zone 6. The deaeration zone 6 is provided with one or more mixers 8 and a plurality of stripping steam inlets or jets 10 and 10' which discharge in the lower portion of a liquid phase maintained in the lower portion of the deaeration zone. Although not specifically shown, it is contemplated employing hollow shaft mixers and paddle blades to permit introducing stripping steam into the liquid through a plurality of small openings or jets in the blade of the paddle or through a distributing device associated adjacent to the paddles of the mixer. The stripping steam inlets 10

and 10' are supplied with steam at a pressure of about 50 psig. by conduits 12 and 14. The deaeration zone is maintained in the upper portion thereof at a pressure below atmospheric pressure, about 14.0 psia., and a temperature of about 240°F. Stripping steam and air released from the froth and liquid phase in the deaeration zone are removed from the upper portion thereof by conduit 16. The deaerated liquid phase is withdrawn from substantially the bottom of zone 6 and passed by conduit 18 to pump 20. Conduit 22 is provided for introducing flushing oil to pump 20. Pump 20 is employed for passing the liquid phase withdrawn from the bottom of the deaeration zone to storage tanks or the diluent mixing zone of the process as hereinafter described. From pump 20 the liquid effluent of the deaeration zone is passed in one embodiment at a temperature of about 221°F. by conduit 24 to a cooler 26 wherein the temperature of the effluent is reduced to a temperature of about 180°F. prior to passing the effluent to storage drum 30 by conduit 28 when desired. When passing the liquid effluent from the deaeration zone directly to a diluent mixing zone without passing through the storage facilities, the deaerated liquid phase is passed through bypass conduit 32 to conduit 34 connected to the diluent mixing zone.

In the specific embodiment of the method of this invention the storage facilities represented by zone 30 is an accumulation zone so that the feed rate of the deaerated liquid phase to the diluent mixing and dehydration zones will be substantially constant irrespective of the quantity of deaerated froth comprising the deaerated liquid phase obtained from one or more deaeration zones.

In this specific embodiment the diluent mixing zone

36 is a cylindrical chamber provided with a conical bottom and a withdrawal conduit 40 provided with valve 42 extending downwardly from the conical bottom. A conduit 44 sloped at an angle of at least about 45° from the horizontal and provided with valve 46 is connected to a lower portion of conduit 40 and extends downwardly for communication with the lower intermediate portion of a dehydrating zone 38. Accordingly the diluent mixing and heating zone is juxtapositioned with respect to the dehydrating zone 38 to assure gravity flow of the liquid phase from the mixing zone to the dehydrating zone. Mixing zone 36 is also provided with a suitable heating arrangement or means such as a heating coil represented by coil 48 to which steam is introduced by conduit 50 and removed by conduit 52 to heat the mixing zone to a desired elevated temperature of about 260°F. In addition to the above, steam at an elevated pressure of about 185 psig. is admitted directly to the upper portion or vapor phase of the mixing chamber by conduit 54 as purge or sweep gas to remove any air released from the liquid phase during mixing of hydrocarbon diluent therewith and withdrawn through the vent conduit. Furthermore, the mixing chamber is provided with suitable stirring means 56 to mildly stir the liquid phase therein and maintain the finely divided solid material which tends to settle out rapidly upon mixing of the hydrocarbon diluent in suspension in the liquid phase for passage to the dehydrating zone 38 and eventually recovery therefrom.

In the specific method of this invention the deaerated liquid phase obtained from the deaeration zone is passed by conduit 34 to the upper portion of the mixing zone, but beneath the inlet of the high pressure sweep steam admit-

ted by conduit 54. The diluent oil, a relatively low-boiling coker naphtha material, at a temperature of about 370°F. is passed by conduit 58 into a lower portion of the mixing zone and beneath the point of introduction of the deaerated liquid phase thereto by conduit 34. In the mixing zone the deaerated liquid phase containing the oil extract or bitumen is diluted with the relatively low-boiling naphtha and heated to an elevated temperature of about 260°F. and thereafter passed by gravity to the dehydration zone 38 by conduits 40 and 44. In the dehydration zone, oil is separated from water and entrained solid particles with the oil being recovered from the upper portion of zone 38 by conduit 60 and the water phase with suspended solids being recovered from the bottom of zone 38 by conduit 62. Cooling water is added to the bottom portion of zone 38 by conduit 64 to reduce the temperature of the withdrawn water stream to a temperature of about 150°F.

It is to be understood that the method of this invention contemplates employing a plurality of deaeration zones in conjunction with a plurality of diluent mixing zones and dehydration zones with a diluent mixing zone associated with each dehydration zone to provide for mixing of the diluent material and gravity flow of the liquid phase containing diluted bitumen, water and suspended solids to the dehydration zone.

Having thus provided a general description of the method and means of this invention and given a specific example thereof, it is to be understood that no undue limitations are to be imposed by reasons thereof.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A method comprising in combination passing froth obtained from the water extraction of tar sands and comprising a mixture of oil, air, water and entrained finely divided solid material to a deaeration zone maintained under pressure and temperature conditions suitable to collapse said froth to form a liquid phase comprising oil and water, mixing a relatively low-boiling hydrocarbon diluent material with said liquid phase under elevated temperature conditions and thereafter separating the diluted liquid phase into an oil-rich phase and a water-rich phase in a dehydration zone.

2. In a process for recovering bitumen from tar sands employing hot water extraction of the tar sands to form a froth comprising oil, air, water and entrained sand particles, the improved method for treating the froth which comprises passing the froth to a deaeration zone maintained below atmospheric pressure in at least the upper portion thereof and a temperature not substantially above the boiling point of water at the pressure conditions maintained in the deaeration zone to effect release of entrapped air from the froth and form a liquid phase in the lower portion of the deaeration zone, introducing steam at an elevated temperature to the liquid phase in the deaeration zone to strip air therefrom, removing stripped air from the upper portion of the deaeration zone and recovering a deaerated liquid phase comprising oil and water from the bottom of the deaeration zone.

3. A method for treating a froth comprising oil, air,

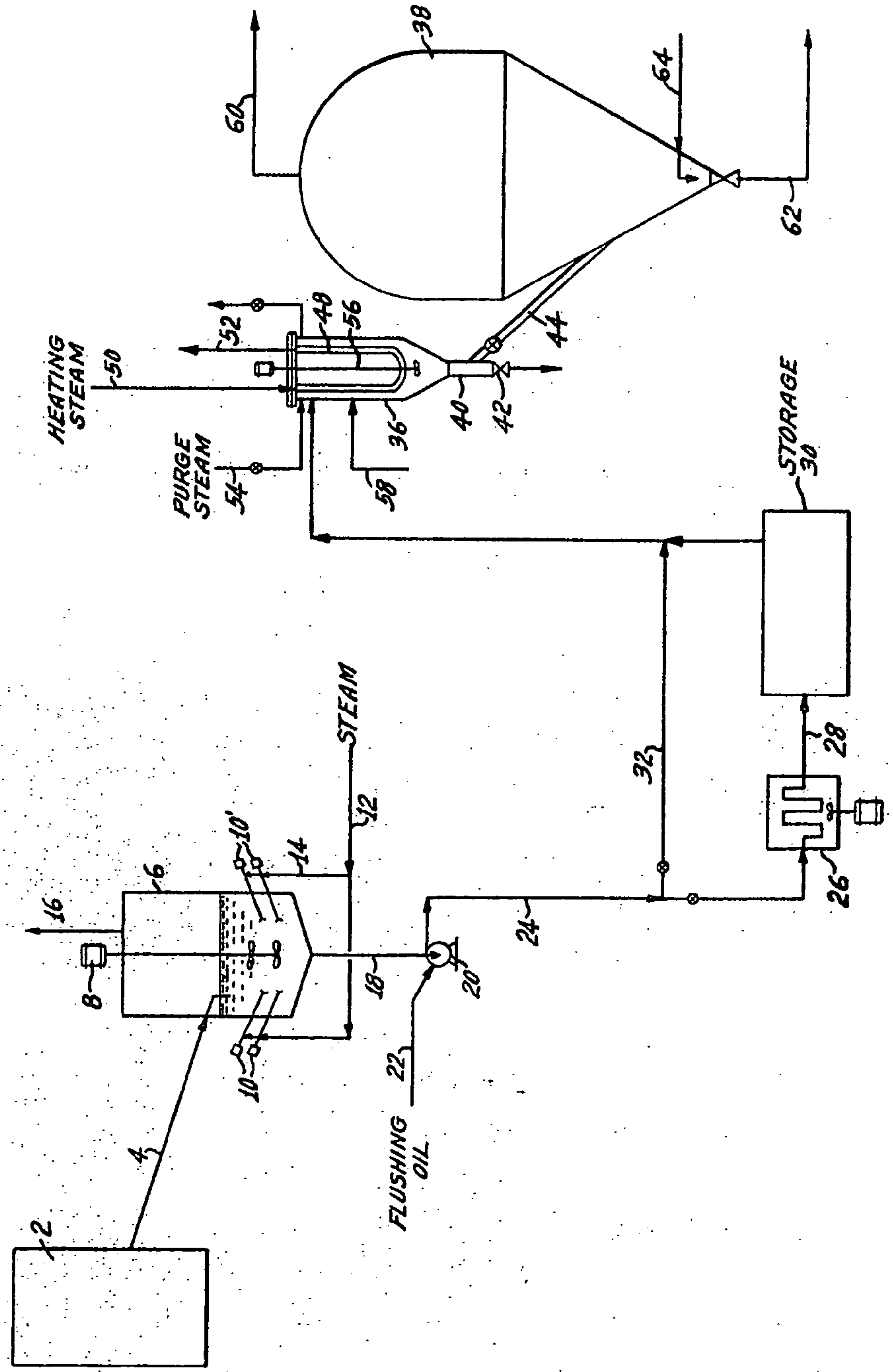
water and entrained finely divided solid particles which comprises subjecting the froth to subatmospheric pressure in the presence of steam at an elevated temperature sufficient to remove air and form a liquid phase comprising oil, water and entrained solid particles, introducing steam to the liquid phase while agitating the liquid phase to effect further removal of entrapped air therefrom, recovering a liquid phase from the deaeration zone sufficiently free of entrained air to avoid explosion hazards upon mixing of a low-boiling naphtha diluent material therewith, mixing a low-boiling naphtha diluent material with the liquid phase recovered from the deaeration zone in a diluent mixing and heating zone maintained under elevated pressure and temperature conditions, and passing the liquid phase containing hydrocarbon diluent by gravity from the mixing zone to a dehydration zone for separation of oil from water and entrained solid material.

4. A method for recovering oil from a froth comprising oil, air and water which comprises deaerating the froth in the presence of steam to form a deaerated liquid phase, introducing the deaerated liquid phase into the upper portion of a liquid phase in a diluent mixing and heating zone, introducing a lower boiling hydrocarbon diluent into a lower portion of said liquid phase in said mixing zone while stirring and heating said liquid phase to an elevated temperature in the range of from about 200°F. to about 300°F., introducing steam at an elevated pressure to the mixing zone above the liquid phase therein to maintain the space above the liquid phase substantially free of air and withdrawing for flow by gravity to a dehydration zone a diluted liquid phase from the bottom of the mixing zone at an elevated temperature suitable

for separation of oil from water in said dehydration zone.

5. A method for recovering oil from a froth comprising oil, air and water, which comprises collapsing said froth in the presence of steam to remove air therefrom and produce a liquid phase comprising oil, water, and entrained solid particle material, diluting said liquid phase with a low-boiling hydrocarbon material, heating the diluted liquid phase to an elevated temperature while maintaining the pressure from about 5 to about 50 pounds above the vapor pressure of the mixture, passing the diluted liquid phase at an elevated temperature and pressure by gravity to a dehydration zone for separation of an oil phase from a water phase and recovering the oil phase for conversion into desired products.

6. A method for recovering oil from a mixture comprising oil, air, water and finely divided solid particle material which comprises passing a mixture comprising oil, air, water and solid particle material to a zone maintained under temperature and pressure conditions suitable to remove air from the mixture in the presence of steam and produce a liquid phase comprising oil, water and entrained solids substantially free of air, heating the liquid phase under elevated pressure conditions to a temperature in the range of from about 200°F. to about 300°F. in the presence of a relatively light naphtha diluent to form a hydrocarbon mixture having a gravity in the range of from about 15 to about 25°API and thereafter passing the mixture to a dehydrating zone for separation of a hydrocarbon phase from a water phase.



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